Chapter 10. External Factors

This Roadmap incorporates the highest scientific priorities of the nation, as described in recent studies by the National Academy of Sciences. These include *Astronomy and Astrophysics in the New Millennium* (Astronomy and Astrophysics Survey Committee, C. F. McKee and J. H. Taylor, co-chairs, 2001) and *Connecting Quarks with the Cosmos: Eleven Science Questions for the New Century* (Committee on the Physics of the Universe, M. S. Turner, chair, 2002).

To uncover the fundamental laws of the Universe, we must draw upon the talents and resources of the entire research and engineering communities. We must seek partnerships that make the best use of scarce resources. Success will require a new mode of collaboration across nations, agencies, academia, and industry.

Traditional disciplinary boundaries must be broken down in order to share information and build models that are broader in scope. *Beyond Einstein* brings NASA to the frontiers of fundamental physics. Many missions will involve experimental and theoretical physicists traditionally supported by other federal agencies.

Partner agencies will include the Department of Energy and the National Science Foundation. The collective knowledge of our universities will be tapped to develop the missions and use them to make discoveries. NASA will serve as the lead on some of the more complex missions and as the facilitator in other missions, relying upon academic, industrial, and international partnerships. Collaborations with international partners will be sought to maximize the use of existing capabilities, thereby minimizing duplication of effort, and to reap the benefits of a competition which leads to the incorporation of the best minds and the best technology from around the world. An example where collaboration is already proceeding is the LISA mission which is a 50/50 split between NASA and the European Space Agency. As an example of interagency cooperation, the Department of Energy is funding technology development for one promising approach to a Dark Energy Probe.

Partnerships and collaborations with foreign countries are increasingly affected by the ever more stringent standards of the International Traffic in Arms Regulations (ITAR). To continue to benefit from international partnerships, we must come to grips with a world that feels ever less secure. This will require more front-end planning and cooperation with the agencies charged with protecting our national interests to keep our missions within cost and schedule constraints.

New knowledge must be shared quickly with the general public. As part of NASA's education initiative, we will seek alliances with the education and communications communities.

Technology is often the factor that limits the pace of progress. A shortfall in technology investment would threaten the development of future missions and increase the risk of technical or programmatic failure.

Investments in the infrastructure that enable researchers to communicate, organize, and share information are crucial to ensure the widest participation in the research effort. These assets include the Deep Space Network, supporting orbital and ground networks, data archival and distribution networks, and high-speed ground links.

It is anticipated that the volume of scientific data in future missions will far exceed existing storage capabilities. This may be accommodated in part by distributed data sets. However, the software tools as well as the connectivity for such distributed systems will require new approaches and architectures for synthesizing these data streams. Continual investment in information technology tools will be required to address the spatial, temporal, and spectral data needed to understand the cosmos. Furthermore, information technology investments to support the on-board control strategies of more capable spacecraft will be essential as we move to an era of constellation or formation flying.

NASA must find new ways to collaborate with industry in the development of critical technologies. Where shared investment makes sense, we need to create mechanisms helpful to such initiatives. A new paradigm is required that allows the government to continue to invest in high-risk areas while planting seeds for “almost ready” technologies that have both government and commercial applications.

The availability of small launch vehicles to place spacecraft into orbit is a growing concern. Cost efficient access to space is required for small payloads and all forms of launch access, both foreign and domestic, must be considered in the future. Concurrently, long-term planning and integration with other launch customers may be needed to pair science missions with like orbital requirements to maximize the use of the remaining expendable launch fleet. The balloon program may also help this situation through refinements of the Ultra-Long Duration Balloon capability to provide up to 100 days of continuous observation time.

Regardless of the orbital strategy chosen, there will be a continuing need for suborbital programs of sounding rockets and balloons to perform experiments and test new technologies and instrumentation. Balloon flights from Antarctic bases are especially productive and depend on continued infrastructure and logistics support from the National Science Foundation.